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ABSTRACT

Research pertaining to the small number of female students in the sciences and mathematics is examined. This research shows that, compared to males, females are not as likely to develop interests in mathematics and science at an early age, are not encouraged by parents and teachers to seek careers in these areas, and have fewer appropriate feminine role-models. (MH)

Gifted Girls: Scientists and Mathematicians of the Future

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Gifted Girls: Scientists and Mathematicians of the Future

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Far fewer women than men pursue careers in mathematics and science. For example, only 3.4 percent of the doctoral degrees earned in the physical sciences (including mathematics and engineering) were awarded to women in 1968-69 (Centra, 1974). There is a growing interest in some sectors in increasing the participation of women in these fields. If today's gifted girls are to be encouraged to consider professional careers, particularly those in science, we must consider what factors have led to differential achievement and interest in these career areas between the sexes.

Although boys and girls do not appear to differ greatly with respect to aptitude or liking for mathematics in the elementary school years (Ernest, 1975), there are sex differences in achievement in high school and college. When mathematics and science courses become optional in high school and college, far fewer females than males elect to take them (Haven, 1970; 1972; Sells, 1976).

The Study of Mathematically Precocious Youth (SMPY) at The Johns Hopkins University has found far more males than females who are mathematically precocious as early as grade seven. Even the girls who are gifted differ from their male cohorts with respect to interest in mathematics, scientific careers, and eagerness to accelerate their educational progress in mathematics and science (Stanley, 1973; Fox, 1975a). In a study of gifted boys and girls matched on measures of mathematical and verbal ability and socio-conomic background factors, boys were significantly more advanced than girls with respect to course-taking in mathematics by the end of the 10th grade (Fox 1976a).

SMPY and the Intellectually Gifted Child Study Group (IGCSG) are interested in fostering the educational development of mathematically gifted students. There appear to be three major factors related to sex difference in achievement, particularly course-taking in mathematics among gifted students. The first factor is related to differential career interests and expectations. The second factor is encouragement from significant others. The third factor is early identification and educational facilitation of the gifted child. Let us consider each of these factors in turn.

Career Interests and Expectations

In a study of the differences between well-above average ability girls who elect or do not elect to take high school mathematics courses, Haven (1972) found that the two most significant predictors of course-taking were the value of mathematics for future studies and careers, and greater interest in the natural sciences than social studies. Girls who elected to take advanced courses in mathematics did so because they saw the courses as directly relevant to their career goals. Thus, differential course taking and related achievement of girls in mathematics is related to differential career interests and aspirations. Presumably these career interests and aspirations are influenced by social-cultural pressures.

As early as grades seven and eight, boys and girls who exhibit high academic potential differ dramatically with respect to career interests and aspirations. More boys than girls aspire to mathematical and scientific careers (Fox & Denham, 1974; Fox, Pasternak, & Peiser, 1976). Not surprisingly, gifted boys more than gifted girls perceive the study of mathematics as relevant to their future goals (Haven, 1972; Fox 1975a).

Although academically talented girls do differ significantly from their male counterparts with respect to expressed career goals, it is important to note that academically able girls also differ strikingly from adolescent girls in general with respect to career interests. In a study using the Strong-Campbell Interest Inventory (Fox, Pasternak & Peiser, 1976), gifted girls showed much stronger interest in science and mathematics on the general interest scales than a random group of adolescent girls and boys did, but less interest than gifted boys. Girls who have well-above average mathematical ability appear to be attracted to both "masculine" and "feminine" career areas.

Thus, the girls who have the greatest potential for achievement in the physical sciences and mathematics appear to experience more conflict in career interests than less able girls or very able boys. This conflict seems to result from the fact that the underlying values of girls are not consistent with their intellectual talents. The majority of women in any sample tend to score higher on measures of social values and lower on theoretical values than men on the Allport-Vernon-Lindzey Study of Values (1970), and this is true of gifted girls as well. Gifted boys, however, tend to score low on the social value scale and high on the theoretical value scale, which is consistent with mathematical and scientific endeavors (Fox, 1976b).

Although it is not completely clear as to why women and men differ so greatly with respect to these interests as early as grade seven, it does appear that many social-cultural influences help to reinforce these differences over time. The support of significant others in the young girl's life may be crucial for resolving this conflict.

The Support of Significant Others

Haven (1972) found that girls who did elect to take mathematics courses in high school were those who received encouragement from parents, guidance counselors, mathematics teachers, and peers. Studies of women who have received the doctorate (Astin, 1969) and of women mathematicians in particular (Helson, 1971; Luchins, 1976) indicate that identification with the father, encouragement from teachers, and parental support were important factors in the development of these women.

In general, how supportive are parents, teachers, and peers of girls' interest in mathematics? In a study of a small sample of mathematically gifted students Astin (1974) found that parents of boys were more likely than parents of girls to have noticed, and fostered, their child's scientific interests. Gifted boys are more likely than gifted girls to perceive their parents as favorable toward accelerative educational experiences in mathematics (Fox, 1975a). Informal obervations in counseling situations suggest the differential perceptions of parents' attitudes are correct.

Whether or not gifted girls receive special encouragement at home to aspire towards careers in the sciences, they are not likely to get special career counseling in this direction at school or encouragement from teachers. Since many teachers believe that boys are inherently better at mathematics and science than girls (Ernest, 1975), they are not likely to notice and encourage those girls who are talented. Casserly (1975) found that some high school guidance counselors admitted to discouraging gifted girls from pursuing advanced mathematics and science courses because careers in science and mathematics were not realistic pursuits for women.

Even in these supposedly "liberated times" gifted girls may find little support from peers for showing interest and aptitude in mathematics. Clearly, many gifted girls anticipate peer rejection for accelerating their progress in mathematics (Fox, 1974a, 1974b). Solano (1976) has found that the girls' fears are justified. Both teachers and peers have a negative view of mathematically gifted girls.

In a study of Wisconsin high schools, Fennema (1976) found sex differences in mathematics achievement in schools where students tended to label mathematics as a male domain, but no sex differences in achievement in schools where mathematics was not masculinely stereotyped. A study of female college students found that those majoring in mathematics and the sciences were less likely to view these areas as unfeminine than were women majoring in the more traditionally female areas (Hawley, 1972). Thus, the perception of mathematics as a male domain is a factor which affects female aspirations and this perception is undoubtedly shaped by parents, teachers and peers.

Thus, girls aspire less than boys toward careers in mathematics and science partly because their own early interests deter them, but perhaps partly because they receive so little encouragement to do so. Even girls who are very talented and interested may find the road to achievement in mathematics and science difficult unless they develop a strong sense that liking mathematics and science is not unfeminine and inappropriate. At this point the problem seems circular. Girls avoid mathematics and science in high school, college, and graduate school because they perceive it as unrelated to their career goals. As long as they avoid the courses, they are unable to compete for careers in these areas at a later time. The fewer women who aspire and attain careers in the sciences, the less likely attitudes and views of these career areas as "masculine" will change.

As long as these career areas as perceived as masculine, only a few young women will be encouraged to aspire toward them.

Education for the Gifted

The question of interest, then is how to break the chain. If society is truly committed to encouraging women to develop all their talents more fully, how can this be done? Removing external barriers, such as sex discrimination in hiring, will not automatically cause women to surge forth to fill the ranks of scientists.

Affirmative action programs for women should be encouraged to become advocates of special education for gifted and talented students. Several studies clearly indicate that programs for gifted and talented students can lead to greater achievement in mathematics for gifted girls.

Casserly, (1975) studied twelve high schools in the United States that had twice the national percentage of girls enrolled in Advanced Placement courses in mathematics and the physical sciences. Her findings are very enlightening. These schools were characterized by one or both of the following:

1. These schools had teachers of such courses who actively recruited girls for the advanced mathematics and science courses. These teachers were conscious of the negative aspects of sex-role stereotypes and demanded high level performance from males and females alike.
2. Many of the girls in these classes had been tracked as early as grade four into special programs for superior students. Thus, for them the taking of advanced courses was a natural sequence in a gifted program.

Special accelerated classes for mathematically gifted students designed by SMPY and IGCSG at The Johns Hopkins University have been successful in promoting achievement of gifted boys and girls. Girls have been extremely successful in such programs when the teachers have been females or the classes integrated into a school system program for the gifted (Fox, 1974b; 1975b; 1976c; Stanley, 1973; 1976).

In 1973, twenty-six mathematically gifted seventh grade girls participated in an accelerated algebra summer program. The class was taught by a woman and included some career counseling. Although 18 girls learned Algebra I to a level of apparent mastery, only 11 were allowed by their schools to take Algebra II the following year. By the end of the tenth grade, however, fifty percent of these girls were accelerated in mathematics by at least half a year, most of them by one full year. This degree of acceleration was compared with that of gifted boys and girls who had not been in the accelerated program. (The comparison groups were matched on measures of numerical and verbal aptitude and socio-economic factors.) The gifted boys were about as accelerated as the girls in the special program. The comparison group of gifted girls was considerably less accelerated than were the boys or the girls in the special program. Thus, early intervention of an accelerative rather than remedial nature can help lessen the achievement gap between the sexes at grade 10 (Fox, 1976a).

The studies at Hopkins suggest that girls are more reluctant than boys to accelerate themselves in mathematics in ways that set them apart from their peers. If the accelerated mathematics learning can occur in a supportive social situation and one in which there is a sizeable group of girls involved, the girls will participate and succeed. Casserly's study also concluded that the success of early tracking into gifted programs for girls was related to social factors. Girls formed a reinforcing support system for each other.

The studies at Hopkins also suggest that career education for gifted girls is an important component of successful gifted programs. In a pilot study of a career education and mathematical skills project for gifted fifth- and sixth-grade boys and girls, two male and two female mathematicians taught short courses on topics such as statistics, geometry, probability, and computer science. Students in the program, particularly the girls, became more positive towards mathematics and more interested in careers in mathematics and computer science (Fox, 1976d).

Conclusions

On the basis of current evidence it appears that, in order for more women to become scientists and mathematicians, girls must develop interests in these career areas at an early age, so that they do not self-select themselves out of mathematics and science courses in high school. Girls will be more likely to develop these career interests if they are encouraged by parents and teachers to view these careers as realistic goals for women. Contact with appropriate feminine role-models is likely to promote this end.

Since most girls value social interests and careers of a social service nature, attempts to teach girls about the ways in which mathematics and science can be used to solve social problems would seem desirable. Thus, it might be appropriate to initiate courses in applied mathematics at the junior- and senior-high school levels. Statistics and computer science both have great appeal to young girls and boys. Courses in environmental problems, psychology, oceanography, medical science, operations research, health statistics, and so forth, could be offered, perhaps as mini-courses, to stimulate interest in the applications of mathematics and science to real world problems. The teaching of such courses might greatly enhanced by visits with scientists in their laboratories.

Teachers of mathematics and science at all levels should examine their own classroom behaviors to see how they can foster greater interest in mathematics among girls. Teachers should also examine their textbooks for sexism, as well as their own casual remarks in class. They might make an effort to include a unit on the history of mathematics and science which includes mention of the contributions of women, as well as men. The sex-role stereotyping of mathematics as a male domain must give way.

Mathematics and science teachers could join forces with counselors to create special career counseling programs for girls. Girls may need special counseling to help them see how important mathematics and science courses are as background for a wide variety of careers. Women scientists and other professionals might visit the school to talk with girls about their careers. Teachers and counselors might make special efforts to encourage girls and their parents to think about educational and career opportunities in fields such as engineering, statistics, accounting, and so forth.

Career education is an important need for all of today's youth. Effective career education programs need not be costly. Many communities have access to persons with varied skills and interests who might be willing to donate time for such a worthwhile cause. Some large companies, labor unions, professional and educational organizations, and other community organizations might be quite willing to sponsor certain aspects of such a program. Schools which devise truly innovative programs might be eligible for federal funds.

Mathematics and science are exciting career fields. Women, however, need help in learning that jobs with intellectual and social challenges in science and mathematics exist for them, as well as for men. It seems clear that in order to accomplish this goal, special programs for the gifted must be provided for students, particularly girls, at an early age and be systematically continued throughout the school years. Homogeneously grouped classes, early tracking for academic programs, and accelerative mathematics and science courses combined with career education and counseling can, indeed, produce more women scientists and mathematicians for the future.

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